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Ecological Indicators 1 (2001) 11–20

ECOLOGICAL INDICATORS

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Environmental indices and the politics of the Conservation Reserve Program

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Accepted 7 March 2001

Abstract

Environmental indicators can be used to target public programs to provide a variety of benefits. Social scientists, physical scientists, and politicians have roles in developing indicators that reflect the demands of diverse interest groups. We review the US Department of Agriculture's Conservation Reserve Program (CRP), the largest agricultural conservation program the United States, to determine how a set of environmental indicators were developed and used, and assess results of their application. The use of such indicators has helped the CRP increase and broaden the program's environmental benefits beyond erosion reduction, which was the primary focus of early program efforts, to meet other demands. This case study provides an example about how integration and assessment for the purpose of managing public resources requires more than natural science disciplines. Social science can help explain how public values influence what information is collected and how it is interpreted. Examples are given to show how the indices used for the CRP integrated science, politics and social values. In the end, the environmental benefits index (EBI) used to target US$ 20 billion of CRP funds reflects compromises made between science and policy considerations. It is our intention that studying this index will yield ideas and understanding from the natural science community that develops ecosystem indices about how to better plug in to programs in the future.

Keywords: Environmental index; Indices; Conservation Reserve Program

1. Introduction

Many nations devote resources to develop ecological indicators to ensure that their natural resources remain vital and "healthy". Naturally, the first step is to develop science-based indicators and indices that accurately represent ecosystems. The greatest challenge and need for scientific research likely lies in the study of how to accurately represent complex ecosystem functions. However, this vision of ecological indicators falls short of the goals listed in the sub-title of this new journal: "integrating, monitoring, assessment and management". The Environmental Monitoring and Assessment Program (EMAP) in the United States, for example, paid heed to calls for details where natural sciences were concerned, but the program's early success was curtailed because EMAP did not adequately address multiple warnings by scientific review panels to be more policy relevant (Hyatt and

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1470-160X/01/$ – see front matter © 2001 Elsevier Science Ltd. All rights reserved.
PII: S1470-160X(01)00002-4

Hoag, 1997). Hyatt and Hoag concluded that EMAP stumbled early on, in part, because the administration did not account for how peoples' values affected the collection and interpretation of results.

Most physical scientists probably give little thought to the role of social science in the area of ecological indicators. Yet, it is the public sector that provides inputs (such as funding) for developing indicators and that responds to indicator outputs (by making policies). Therefore, an understanding of how social and natural sciences work together is important. One excellent example is the Conservation Reserve Program (CRP) in the United States. Since 1985, this program has spent over US$ 20 billion to address farmland conservation. That is US$ 20 billion for environmental protection directed by a set of indicators; an index if you will. The program has a *monitoring* component, an index that *integrates* indicators, priority weights on each of the environmental objectives, which functions as an *assessment* tool, and a *management* plan for dealing with outcomes from the index.

The CRP was authorized by the Food Security Act of 1985 and re-authorized in 1990 and 1996. Since then, it has been used on as many as 36 million acres (about 10% of US cropland) at any one time to prevent soil erosion, degradation of water quality, and to preserve wetlands and wildlife habitat. In this article, we describe the evolution of the CRP, with emphasis on the development and application of the environmental benefits index (EBI) that dictates which land is protected, to illustrate the need for both natural sciences and social sciences to integrate, assess and manage a public resource. The EBI is the result of political compromise. The final construct of the EBI reflects both the science of the problem and a complex web of social values.

We present a detailed description below about how the CRP index was developed so that readers can compare it to the more traditional forms of ecosystem indicators. While the index may seem strange, or even inappropriate, it is important to understand the details about its development to fully comprehend how society has chosen to use ecological indices to allocate US$ 20 billion. Understanding what choices were made and why they were made will facilitate more integration of natural sciences in the future when indices are used to manage public resources.

2. The Conservation Reserve Program

The CRP is the largest US agricultural conservation program in terms of acres enrolled and Federal outlays. With about 33.5 million acres under contract (as of October 2000), close to 10% of US cropland is idled under the program, providing water quality, wildlife habitat, and other natural resource benefits (AREI, 2000). For comparison, the National Wildlife Refuge System holds about 15 million acres in the continental United States (USDI, US F&WS, 1999). Fig. 1 shows the distribution of CRP enrollment. Approximately US$ 1.5 billion in annual rental payments will be paid to enrollees in fiscal 2001, in addition to other cost-sharing and technical assistance.

As a voluntary long-term cropland retirement program, the CRP provides participants (farm owners or operators) with an annual per acre rent and half the cost of establishing a permanent land cover (usually grass or trees) in exchange for retiring highly erodible and/or environmentally sensitive cropland from production for 10–15 years. Currently, the bulk of enrollment occurs under a competitive-bid process, whereby offers are ranked according to the expected environmental benefits and cost to the government. However, that has not always been the case.

3. The evolution of the EBI

3.1. 1985: New directions for conservation programs

There are many benefits extolled on soil conservation. Originally, Congress declared that the primary goal of the CRP was to reduce soil erosion on highly erodible cropland. Secondary objectives included improving water quality, reducing sedimentation, creating wildlife habitat, curbing the production of surplus commodities, and providing income support to farmers. Given the massive undertaking of classifying highly erodible lands on farms, collecting bids, establishing conservation cover, enforcement and other details of getting the new program underway, declaring soil conservation as the primary objective made the job of program implementation much simpler, since no one had to decide whether soil conservation was more or less important than water quality.

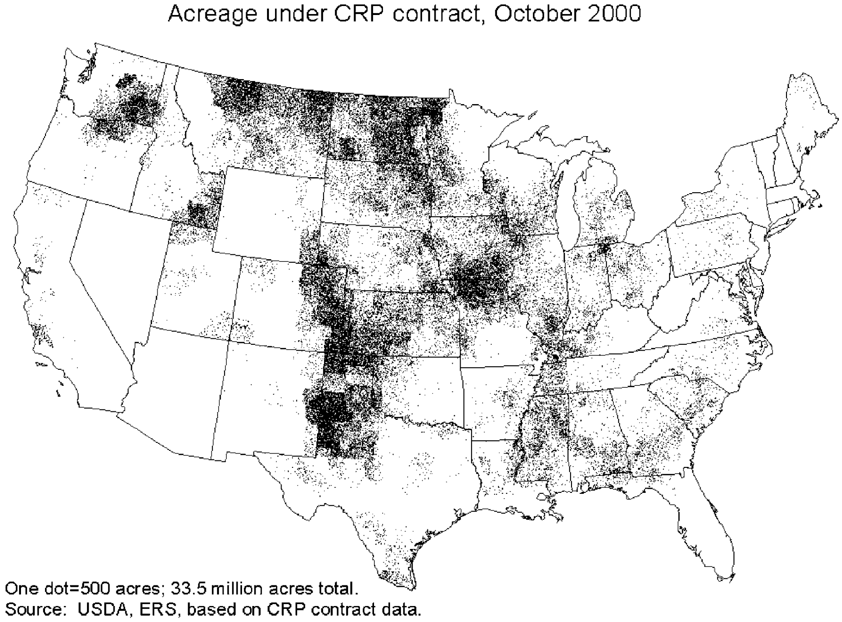

Fig. 1.

To enroll in the program, a landowner applied at the county USDA office during the designated sign-up period, indicating the yearly rental payment he or she would accept. Once all applications for a particular sign-up period were received, they were compared to the maximum acceptable rental rates (MARR) that USDA set for pre-designated regions (multi-county). An application was accepted if the erodibility criteria were met and the rental rate bid was below the MARR. For a field to be eligible for the CRP, at least two-thirds of it had to meet one of three basic criteria used to define "highly erodible" (Lee and Goebel, 1986). A massive monitoring and enforcement program was also developed, but those details are beyond the scope of this paper.

During the period, 1986–1989 nine sign-up periods were held, and a total of 33.9 million acres were enrolled (Table 1). Enrollments were concentrated primarily in the Northern Plains, Southern Plains, and Mountain States. Soil erosion was reduced by an estimated 19 t per acre per year on the enrolled land (ERS, 1994).

During this period concern was voiced that the combination of eligibility criteria and the rental bid acceptance procedure was giving too much emphasis to lower-productivity land in the Plains and to on-site problems such as loss of soil productivity, and not enough to off-site environmental problems (Benbrook, 1988; Ogg, 1986; Ervin, 1989; Crutchfield, 1989). Evaluation of enrollment indicated that benefits from improvements in water quality and wildlife habitat were greater, on a per acre basis, than from enhanced soil productivity (Ribaudo et al., 1990). An investigation by the US General Accounting Office (GAO) concluded that the cost-effectiveness of the CRP could have been enhanced if USDA had managed the program to address the full range of CRP objectives rather than focusing on soil erosion and maximizing enrollment to meet Congressionally-set enrollment levels (US GAO, 1989). Only 13% of soil erosion in the regions where enrollment was greatest was from water (the rest from wind). Water erosion causes greater damages to water quality, recreation, and wildlife than wind erosion (US GAO, 1989).

The crux of the problem was that the basis for relating action (enrollment) to outcome (program goals) did not exist for all program objectives (Reichelderfer and Boggess, 1988). If the program indeed had only one "primary" objective to reduce soil erosion, it did very well. However, many people believed

Table 1
EBI component scores for general sign-up CRP (estimated and actual)[a]

Sign-up	Acres enrolled	Water quality (N2) ≤100	Soil erodibility (N3) ≤100	Air quality (N5) ≤35	Priority area (N6) ≤25	Sum of the four ≤260
1	754000	23	63	8	4	98
2	2771000	19	63	13	4	99
3	4703000	21	55	13	4	93
4	9478000	22	52	11	4	89
5	4443000	19	52	11	5	87
6	3375000	18	49	11	5	83
7	2605000	20	49	11	6	86
8	2463000	21	43	10	6	80
9	3330000	20	44	10	6	80
10	475000	30	50	6	6	92
11	998000	29	44	6	4	83
12	1027000	30	53	6	7	96
13	610000	28	61	5	8	102
15	16852000	37	53	12	9	111
16	5923000	42	42	14	13	111
18	4823000	35	37	13	14	99
20	2460000	38	42	12	12	104

[a] Source: Barbarika and Smith (2000).

the secondary objectives should be on par with soil conservation, thus, a new multi-objective index was needed because the technical relationships between production and water quality, sedimentation, and fish and wildlife were not captured by the enrollment criteria, which focused on highly erodible cropland and soil erosion. For example, Ribaudo (1986) showed that targeting conservation programs on the basis of soil erosion alone missed most watersheds impaired by agricultural pollutants.

3.2. 1990: FACTA redirects the CRP

In 1990, the Food Agriculture, Conservation and Reform Act (FACTA) extended the CRP, with some changes, and USDA made substantial changes in program operation. One of the most important changes was that Congress asked that a more complete range of environmental goals be considered in the enrollment process. Environmental improvements besides soil erosion would no longer simply be a residual benefit. USDA developed and applied an EBI, designed to better proxy the range of environmental benefits sought by the program. The EBI was developed consistent with section 1234(c)(3) of the Food Security Act of 1985 which provided that "in determining the acceptability of offers the Secretary may take into consideration the extent to which enrollment of the land that is the subject of the contract offer would improve soil resources, water quality, wildlife habitat, or provide other environmental benefits". A technical team led by USDA's Economic Research Service (ERS), and including other USDA agencies, the Environmental Protection Agency, and the Fish and Wildlife Service, developed the EBI (Osborn, 1997). The first EBI included terms for:

- Improving surface water quality (a function of water erosion, runoff, and population)
- Improving ground water quality (a function of soil leachability and population getting drinking water from wells)
- Maintaining soil productivity (a function of soil loss tolerance rate, relative productivity, and average county dryland cash rent)
- Assistance to producers with potential problems implementing conservation compliance (a function of erodibility index)
- Acreage planted to trees (a function of fraction of acres in bid that would be planted to trees)
- Acreage within identified critical water quality problem areas (a function of acres in bid located in a water quality area and population)

- Acreage within conservation priority areas (CPA) designated by Congress (a function of the fraction of acres bid located within a CPA and population).

Since cropland that is not highly erodible might provide significant environmental benefits, the eligibility criteria were expanded to include State water quality areas, designated conservation priority areas, and designated well-head protection areas.

When a landowner submitted a CRP bid, NRCS provided objective data for each of the EBI factors for the associated land. At the close of a sign-up period, the data for each offer were submitted to Washington, DC and the EBI for each offer was consistently calculated. Each factor was divided by a term representing the estimated government cost of enrolling the bid, and standardized so that each term had the same mean and standard deviation. Ratios were summed for each bid, and bids with the highest ratios were accepted until the enrollment acreage objectives were met.

Each of the factors received an equal weight. Policymakers refused to explicitly judge the relative weights appropriate for each part of the index, deferring to the committee of technical experts that had devised the index. The technical experts could only agree on equal weights. Babcock and coworkers argued that equal weighting is a rational choice given the absence of guidance from policymakers (1995). In addition, estimates of where future enrollments were likely to occur using the new procedures were apparently acceptable to policymakers. If equal weighting had not produced a satisfactory geographic shift, it seems likely that factor weights would have been developed.

To better account for environmental benefits, further refinements were made starting with the 13th sign-up in 1995. In particular, the EBI was revised to explicitly account for benefits to wildlife (US GAO, 1993). The CRP was being seen as major boon to wildlife, and such benefits were believed to be substantial (Wildlife Management Institute, 1994). The 13th sign-up introduced an EBI comprised of five factors. Four characterized the environmental contribution of each parcel offered by landowners. The fifth accounted for the cost to the government of accepting the bid. For the first time the factors were weighted to reflect what were believed to be the most desirable outcomes of the program. The EBI was not meant to be a rigid index, but to be adjusted and improved depending on the progress of sign-ups, perceived deficiencies, and/or changed priorities (Osborn, 1997). The factors and their weights (indicated by the maximum number of points) were:

- Water quality protection — maximum of 20 points
- Creation of wildlife habitat — maximum of 20 points
- Soil erodibility — maximum of 20 points
- Tree planting — maximum of 10 points
- Cost-factor — annual rental rate bid

The score for the parcel was the sum of the first four factors divided by the cost-factor. Each bid was subject to a maximum annual per acre rental payment that the government would accept (bid cap). Bids exceeding the cap were rejected at the county level. Cropland eligible for the program was further extended to cropland prone to scour erosion and periodic flooding, cropland suitable for riparian buffers and vegetative filter strips, small farmed wetlands, and any cropland in the Chesapeake Bay, Great Lakes, and Long Island Sound watersheds, and other designated conservation priority areas. In addition, certain partial-field bids (e.g. filter strips, shallow water areas for wildlife, field windbreaks, shelter belts, and other specific practices) automatically received maximum environmental factor scores.

3.3. 1996: The most refined EBI yet

The Federal Agriculture Improvement and Reform (FAIR) Act of 1996 authorized the Secretary of Agriculture to enroll land in the CRP up to a maximum of 36.4 million acres through the year 2002. In early 1997, USDA finalized rules for the long-term future of the CRP to "cost-effectively target the CRP to more environmentally sensitive acreage" (Federal Register, 19 February 1997). The EBI was modified for the 15th sign-up to meet this goal.

Six environmental factors were included in the EBI, plus a cost-factor (Osborn, 1997). The theoretical maximum EBI score was 600 points, based on the following:

- N1: Wildlife habitat benefits (100 points maximum). This factor was based on vegetative cover, importance to Federal or state threatened, endangered, or candidate species, proximity to wetlands, proximity to other protected wildlife habitat, and size of the area offered.

- N2: Water quality benefits from reduced water erosion, runoff, and leaching (100 points maximum). This factor was based on whether the offered acres are located in a Federal or state-identified area where crop production contributes to ground water or surface water quality impairment, ground water quality protection, surface water quality protection, and water quality improvements associated with wetland enrollment in the offer.
- N3: On-farm benefits of reduced wind or water erosion (100 points maximum). This factor was proportional to the higher of the wind or water erodibility of the soils in the offer. The higher the erodibility, the higher the potential for erosion that can reduce soil productivity.
- N4: Long-term benefits of certain practices that will likely extend beyond the contract period (50 points maximum). This factor recognized that certain practices such as tree cover are likely to remain on the land beyond the 10–15 years of the CRP contract. Practices with the longest expected retention, such as new hardwood trees, received the most points.
- N5: Air quality benefits from reduced wind erosion (25 points maximum). This factor was proportional to the wind erodibility of the soils in the offer and the distance-weighted population that could be most affected by windblown dust from the land offered.
- N6: Benefits from enrollment in conservation priority areas when the offer significantly contributes to the priority area concern (25 points maximum). This factor awarded points to offers that were located within national or state CRP conservation priority areas established for wildlife, water quality, or air quality purposes — provided the points achieved for the corresponding national ranking factor (e.g. N1, N2, or N5) were at least 40% of the total possible points for the factor.
- N7: Government costs of the contract (200 points maximum).

The Secretary does not determine the scoring for this factor until after the conclusion of each sign-up. For the 15th sign-up, the cost-factor was set at a 200-point maximum. Greater points were awarded to offers requesting lower annual rent. In addition, up to 10 points were awarded to offers where no Federal outlay for vegetative cover establishment was requested.

CRP eligibility was expanded again to include cropland in national and state environmental priority areas, cropland adjacent to water bodies, cropped wetlands and adjacent cropland. These new rules expanded the universe of eligible lands to more than 240 million acres, about 65% of cultivated cropland.

In response to a review of the EBI of the 15th sign-up, modifications to EBI factors for wildlife habitat, air quality, and cost were made by an interagency committee for the 1997 16th sign-up in order to further increase environmental effectiveness. Modifications to the wildlife habitat factor (N1A) primarily involved adjustments to point values reflecting the wildlife benefits of different vegetative covers. In addition, a new practice that rehabilitates degraded ecosystems was added. The maximum points for the air quality factor (N5) was increased to 35 to better reflect the off-site damages caused by cropland wind erosion. The cost-factor (N7) added a sub-factor to provide up to 15 additional points for offers of less than the maximum rental rate for soils in the offer. However, the weight assigned to the cost-factor was reduced to 150 points. This implied that the cost-factor weight declined from 33% of total possible points in the 15th sign-up to 27% of the new maximum of 560 points. Since the 16th sign-up, relatively minor adjustments within benefit categories have been made though the overall weights have remained unchanged.

4. Assessment of EBI's performance

Was the EBI a suitable environmental index? It certainly does not fit into the traditional literature about environmental indices because it was not designed to describe an ecosystem. One way to address this question is to determine if the money was well spent. Did the EBI and related changes in program eligibility and bid acceptance criteria increase the environmental benefits of the program and achieve a broader set of environmental objectives than erosion reduction, which was the focus of early legislation? One way of measuring this is to look at how the EBI scores for enrolled acres have changed over the course of the program. Osborn (1997) used CRP contract data and the NRI to estimate an EBI for acres enrolled in all previous sign-ups. He found that application of the EBI in the 15th sign-up yielded greater environmental benefits at less cost than earlier sign-ups. The average EBI score for accepted bids was 307 points, 46% greater than the 210-average EBI of the historic CRP. Most of this improvement is owed to improved wildlife habitat benefits and water quality benefits, and decreased rental costs due to enhanced competition for bids by landowners.

Barbarika and Smith (2000) applied a standardized EBI scoring procedure (the one used for the CRP sign-up held in 2000) to land enrolled across all sign-ups to see how some of the expected benefits may have changed over time. Their results are summarized in Table 1. Land enrolled in recent sign-ups likely provides more water quality benefits and benefits related to conservation priority areas than earlier sign-ups, and, to a lesser extent, air quality benefits as well. However, productivity benefits from erosion reduction were greatest in the earliest sign-ups, not surprising given their primary focus then. Of land that was not previously enrolled (re-enrollment occurred after the 1996 FAIR Act), erosion–reduction benefits have declined over the life of the program; increased erosion–reduction benefits realized in some recent sign-ups have come from land that was re-enrolled from previous sign-ups.

A shortcoming of the analyses presented above is the validity of the EBI. Did improvements in the EBI scores of acreage enrolled in the CRP mean that environmental quality has actually improved? The EBI reflects expected environmental benefits, but whether the EBI of a specific bid reflects actual benefits has yet to be determined. Nor is there any follow up to monitor whether environmental quality has improved (US GAO, 1993).

Another shortcoming is whether the benefits obtained by the CRP were worth the costs, even if the EBI was accurate. That is, assuming EBI is accurate, is the design helpful in assessing and managing resources? The cost-effectiveness criteria adopted for the CRP bid assessment process (EBI/government cost prior to the 15th sign-up, cost as a weighted factor starting with the 15th sign-up) do not provide very objective cost/benefit measures to judge whether the program is as efficient as possible at providing desired benefits. However, Hoag (1999), Economic Research Service (1997), and others have summarized financial estimates of costs and benefits of the program for comparison purposes. As shown in Table 2, Hoag found that the program returned most or more than its costs if one considers the environmental damages avoided, preservation of soil productivity and changes in farm income. Non-consumptive wildlife uses, waterfowl hunting and small-game hunting generated the greatest benefits. The Economic Research Service reported that the net social benefit from the 33.9 million acres enrolled in the program in 1990 was estimated to be between US$ 9.7 and 14.5 billion over the life of the program, considering net farm income, value of future timber production, preservation of soil productivity, improved water quality, reduced windblown dust, and enhanced wildlife uses. Wildlife again was the largest benefit category.

Feather et al. (1999) also show how the use of the EBI increased selected recreation benefits

Table 2
Estimated present value of CRP costs and benefits in 1990[a]

Net social benefits (billions US$)		Net social costs (billions US$)	
Increases in net farm income	2.1–6.3	Higher food costs	2.9–7.8
Future timber harvests	3.3	Cover establishment costs	2.4
Preservation of soil productivity	0.6–1.7	Technical assistance	0.1
Surface water quality	1.3–4.2	Net rental payment costs	6.6–9.3
Windblown dust damage	0.3–0.9		
Small-game hunting	1.9–3.1		
Waterfowl hunting	1.4		
Non-consumptive wildlife uses	4.1		
Sub-total	15–25		12–20.1
Net benefit range	High = 8.1	Low = −0.3	

[a] Source: Hoag (1999).

compared with CRP acreage enrolled when acceptance was based primarily on erosion and erosion potential. Through the use of non-market economic benefit models, they found that gains in freshwater-based recreation and wildlife-viewing benefits from shifts in the enrollment pattern exceeded decreased pheasant-hunting benefits. Based on this one analysis, the use of the EBI appears to increase net recreation benefits. However, this analysis is also based on improvements in environmental quality that are assumed and not measured. Freshwater recreation benefits are based on reductions in soil erosion, not on measured changes in water quality. Furthermore, erosion reductions are estimated using the Universal Soil Loss Equation, which estimates average long-term erosion, and are not based on actual reductions. Similarly, improvements in wildlife habitat are based on land-use patterns rather than on observations. Data for linking the CRP directly to pheasant populations were not available (Feather et al., 1999).

5. Implications for index development?

The previous discussion about the EBI shows how government employees developed indices to reflect societal values, but it does not show how disparate values were reconciled in the political process. For example, Babcock et al. (1995) showed that more than 98% of the benefits obtained by the CRP could have been realized with only 27% as much land as was enrolled if water quality had been targeted. He and others found that greater benefits would be received for attributes that are targeted, but that one could not target multiple objectives simultaneously without sacrificing some efficiency. These findings proved to confuse the question about what the index was trying to reflect. Babcock concluded that all indicators should therefore, receive the same weight, which avoids the question of what the CRP index should really be targeting.

In 1988 Reichelderfer and Boggess used a branch of economics called "public choice" to try and determine what the "true" indices were. Public choice characterizes political decisions as an economy where political favors are tacitly bought and sold (Mueller, 1996). They postulated that the people actually developing and voting on the CRP sought to maximize their own utility as follows:

$$\mathrm{Max}\, U(a) = \mathrm{Max}\, U \sum_{i=1}^{7} (W_i O_i)$$

where the utility derived from any one action a (conservation practice) is the sum of that person's objectives (O_i) times the weight they place on each objective (W_i). The weights are of course unrevealed, but the authors showed that it was impossible to maximize any single objective without sacrificing performance in the others. Therefore, they concluded, the CRP did not optimally achieve its stated objectives and must have met a series of unstated political and bureaucratic objectives. For example, while it is not an environmental objective, supply control on farmland might have been what made the program feasible to some politicians' constituents. Hughes et al. (1995) found that the CRP was widely acceptable not because it met everyone's objectives at one time, but because it met at least one objective for so many people.

There are several more objective, but not necessarily more feasible, ways that weights can be derived. Policymakers can select weights based on perceptions of public preference. In the case of the CRP, this did not occur initially. Weights were left to technical experts and politicians, and in its first application, each factor was weighted the same. Feather et al. (1999) suggest the use of valuation models to aid in the development of an EBI that provides some measure of economic efficiency. A set of simulations can be used to compare alternative EBIs to suggest improvements in factors and sub-factors, specifications, and weights. For example, their analysis found that the CRP is producing significantly larger benefits for wildlife recreation than water-based recreation. This might suggest that the weight for the wildlife factor in the EBI be greater than that for water quality. They are currently weighted equally. Alternatively, if decision-makers desired more balance, greater weight would be given to air quality and enrollment in conservation priority areas to encourage enrollment of lands providing these benefits. To fully implement economic targeting of the CRP, research efforts are needed to (1) increase the number of environmental benefits that are evaluated, and (2) improve technical/theoretical approaches used to estimate the benefit models (Feather et al., 1999).

Feather et al. (1999) highlight the impact of population in developing target criteria. Population can be used as a proxy for demand for environmental services. For example, improving the environment near heavily populated areas results in more recreational benefits than the same change in a sparsely populated area. Hence, considering proximity to population when choosing the size of weights in a targeting criterion is likely to improve recreational benefits.

6. Conclusions

An environmental benefits indicator (EBI) has become an integral component of the process for enrolling land into the CRP, the largest US agricultural conservation program in terms of acres enrolled and Federal outlays. It is a tool that the Secretary of Agriculture uses to meet the goals for the program expressed by Congress in Farm Bill legislation. The EBI was not developed solely by scientists seeking to maximize the potential benefits from the CRP, but by a combination of program administrators, physical scientists, social scientists, and politicians trying to meet the demands of diverse consumer groups, the needs of farmers, and the realities of implementing a massive conservation program. The EBI is not static, but is flexible, changing over time as the goals of the CRP have changed, and as better information has become available on its various components. The EBI has been adjusted before every sign-up since it was first used in 1991 (Zinn, 2000). Some changes have been major, but most are minor. Further adjustments can be anticipated as different environmental issues take on greater prominence. For example, some believe the CRP might play a large role in carbon sequestration, (Zinn, 2000). If so, the EBI will be adjusted to account for this.

Several studies have concluded that the use of the EBI has improved the environmental performance of the CRP. However, the utility of the EBI in terms of actual improvements in environmental quality has been assessed to only a limited degree. On-site assessments of at least a sample of the acreage enrolled in the program to determine the levels of environmental benefits achieved would greatly aid in setting EBI scores in future sign-ups.

Detailed assessments of the physical and economic benefits that the CRP provides are needed to determine relative weights for the EBI's components that reflect public preferences. With on-site verification of benefits, and an allocation of weights based on public preferences, the overall efficiency of the CRP would be improved. Similarly, improvements in our understanding of the linkages between land-use and environmental services and the values of those services would improve our ability to identify those indicators that best represent the likely impacts of programs such as the CRP.

Integration and assessment across appropriate natural science disciplines is important for developing an index that describes an ecosystem. However, the CRP case study shows that integration and assessment can include much more. It can include how people value ecosystem attributes and how these values are varied. Social and natural science each play a role in determining what an index will look like when the public is involved.

Acknowledgements

The views expressed are the authors' and do not necessarily reflect those of the Economic Research Service or the US Department of Agriculture.

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